

Exam

Name \_\_\_\_\_

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

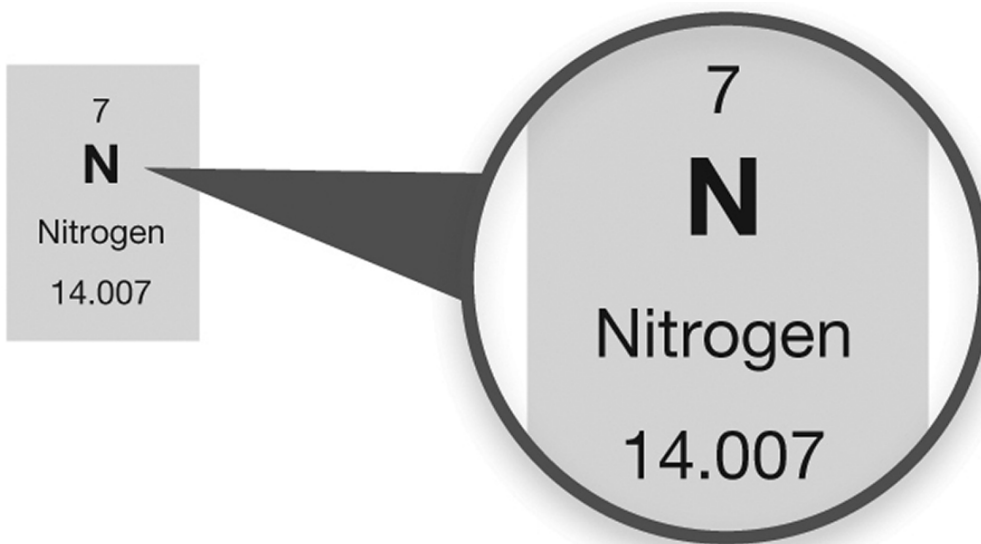
- 1) An atom is best described as
- A) the smallest unit of an element.
  - B) defined by its number of electrons.
  - C) defined by its atomic mass.
  - D) always containing an equal number of protons and neutrons.
  - E) having a nucleus containing protons and electrons.

Answer: A

- 2) Which particle is described incorrectly?
- A) Neutron: Found in the nucleus and 1 atomic mass unit
  - B) Proton: Positively charged and 1 atomic mass unit
  - C) Electron: Negatively charged and negligible mass
  - D) Proton: Found in shells orbiting the nucleus
  - E) Electron: Found in shells orbiting the nucleus

Answer: D

- 3) What information can you determine about the element nitrogen from the periodic table entry shown?



- A) The atomic number for nitrogen is 7 and there are 14 neutrons in the nucleus of a nitrogen atom.
- B) The atomic number for nitrogen is 14.007 and there are 14 neutrons in the nucleus of a nitrogen atom.
- C) The atomic number for nitrogen is 7.
- D) There are 14 neutrons in the nucleus of a nitrogen atom.
- E) The atomic number for nitrogen is 14.007.

Answer: C

- 4) An anion is formed when
- A) an atom loses one or more positively-charged protons.
  - B) an atom gains one or more negatively-charged electrons.
  - C) an atom loses one or more negatively-charged electrons.
  - D) an atom has an equal number of positively-charged protons and negatively-charged electrons.
  - E) an atom gains one or more positively-charged protons.

Answer: B

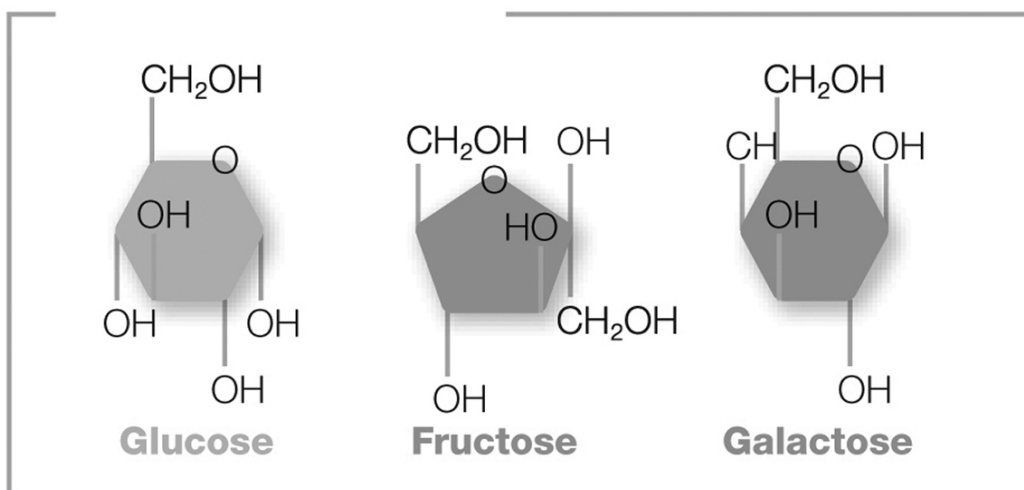
- 5) Isotopes are atoms of the same element that differ in
- A) the number of neutrons found in the nucleus.
  - B) the number of protons and neutrons found in the nucleus.
  - C) the number of electrons orbiting the nucleus.
  - D) the number of protons and electrons found in the atom.
  - E) the number of protons found in the nucleus.

Answer: A

- 6) A feature of many of the isotopes that are used in the field of medicine is that the isotopes are radioactive. What does this mean?
- A) Anionic forms of the atoms are used.
  - B) Cationic forms of the atom are used.
  - C) The atoms with the greatest atomic mass are used.
  - D) The nucleus of the isotope is unstable and breaks down over time.
  - E) The same number of atoms are arranged into different molecular structures.

Answer: D

- 7) The pictured molecules both contain six carbon atoms, twelve hydrogen atoms, and six oxygen atoms ( $C_6H_{12}O_6$ ). However, these atoms are arranged differently in each molecule. What are these molecules called?



- A) anions
- B) R groups
- C) functional groups
- D) isomers
- E) isotopes

Answer: D

- 8) Which of the following is an organic compound?
- A) carbon dioxide (CO<sub>2</sub>)
  - B) methane (CH<sub>4</sub>)
  - C) ethanol (C<sub>2</sub>H<sub>6</sub>O)
  - D) carbon dioxide (CO<sub>2</sub>), ethanol (C<sub>2</sub>H<sub>6</sub>O), and methane (CH<sub>4</sub>)
  - E) ethanol (C<sub>2</sub>H<sub>6</sub>O) and methane (CH<sub>4</sub>)

Answer: E

- 9) Which functional group is incorrectly matched with its structure?
- A) ether: R-CH<sub>3</sub>
  - B) amino: R-NH<sub>2</sub>
  - C) phosphate: R-PO<sub>4</sub><sup>2-</sup>
  - D) carboxyl: R-COOH
  - E) alcohol: R-OH

Answer: A

- 10) Which of the following is incorrectly matched?
- A) Base: Release hydroxide ions (OH<sup>-</sup>) in an aqueous solution
  - B) pH: Measure of the acidity or basicity of a solution
  - C) Acid: Release hydrogen ions (H<sup>+</sup>) in an aqueous solution
  - D) Salt: Formed by the combination of hydrogen ions (H<sup>+</sup>) and hydroxide ions (OH<sup>-</sup>)
  - E) Water: Is the solvent in aqueous solutions

Answer: D

- 11) Pure water is defined by
- A) a neutral pH of 7 and an equal number of H<sup>+</sup> and OH<sup>-</sup> ions.
  - B) a neutral pH of 7.
  - C) a neutral pH of 7, and equal number of H<sup>+</sup> and OH<sup>-</sup> ions, and its ability to serve as a pH buffer in solutions.
  - D) an equal number of H<sup>+</sup> and OH<sup>-</sup> ions.
  - E) its ability to serve as a pH buffer in solutions.

Answer: A

- 12) Compared to a solution with a pH value of 4, a solution with a pH value of 2 has \_\_\_\_\_ H<sup>+</sup> ions.
- A) half as many
  - B) the same number of
  - C) one hundred times as many
  - D) one hundred times fewer
  - E) twice as many

Answer: C

- 13) A compound which stabilizes pH by absorbing or releasing H<sup>+</sup> ions is called a(n)
- A) acid.
  - B) buffer.
  - C) salt.
  - D) base.
  - E) solute.

Answer: B

14) Which statement is true about valence electrons?

- A) Valence electrons participate in chemical reactions, and interactions between valence electrons in reacting atoms determine what kind of chemical bond is formed.
- B) Valence electrons are found in the innermost shell.
- C) Valence electrons are found in the innermost shell and participate in chemical reactions.
- D) Valence electrons participate in chemical reactions.
- E) Interactions between valence electrons in reacting atoms determine what kind of chemical bond is formed.

Answer: A

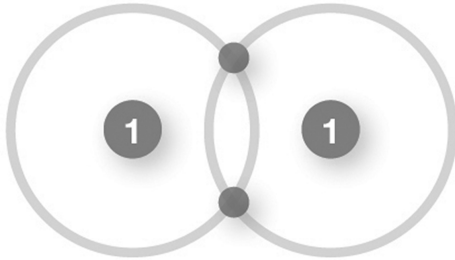
15) Ionic bonds

- A) form when electrons are transferred from atom to another.
- B) are electrostatic forces of attraction between oppositely charged ions.
- C) only exist as ions in solution.
- D) form when electrons are transferred from atom to another and only exist as ions in solution.
- E) are electrostatic forces of attraction between oppositely charged ions and form when electrons are transferred from atom to another.

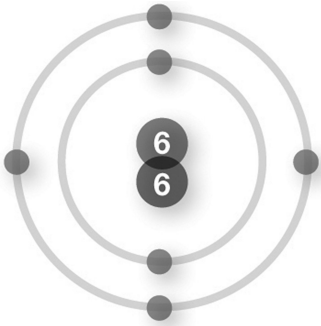
Answer: E

16) Which of the following shows an ionic bond?

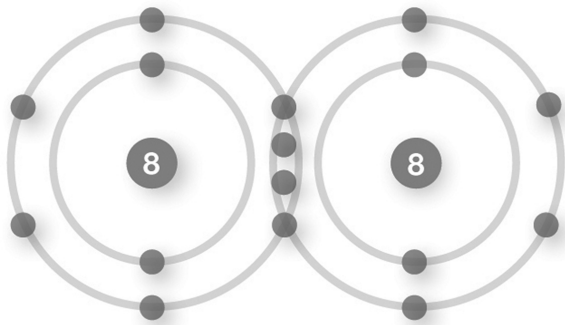
A)



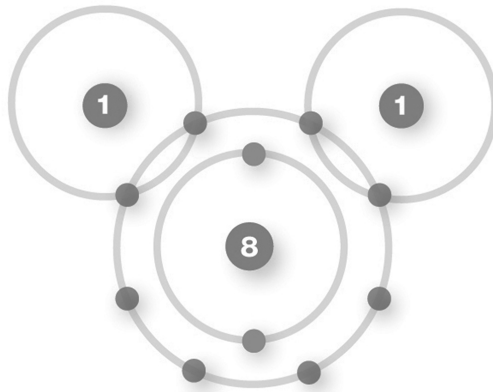
B)



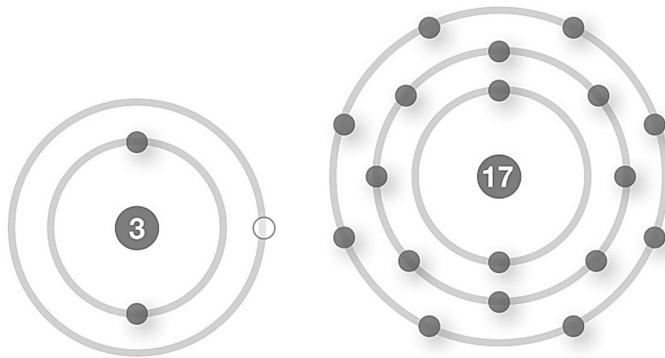
C)



D)



E)



Answer: E

17) Electrolytes

- A) are ionic compounds dissolved in solution.
- B) include acids, bases, and salts.
- C) include acids, bases, and salts, are ionic compounds dissolved in solution and are involved in regulating the nervous system, heartbeat, blood volume and water balance in the body.
- D) are ionic compounds dissolved in solution and are involved in regulating the nervous system, heartbeat, blood volume and water balance in the body.
- E) are involved in regulating the nervous system, heartbeat, blood volume and water balance in the body.

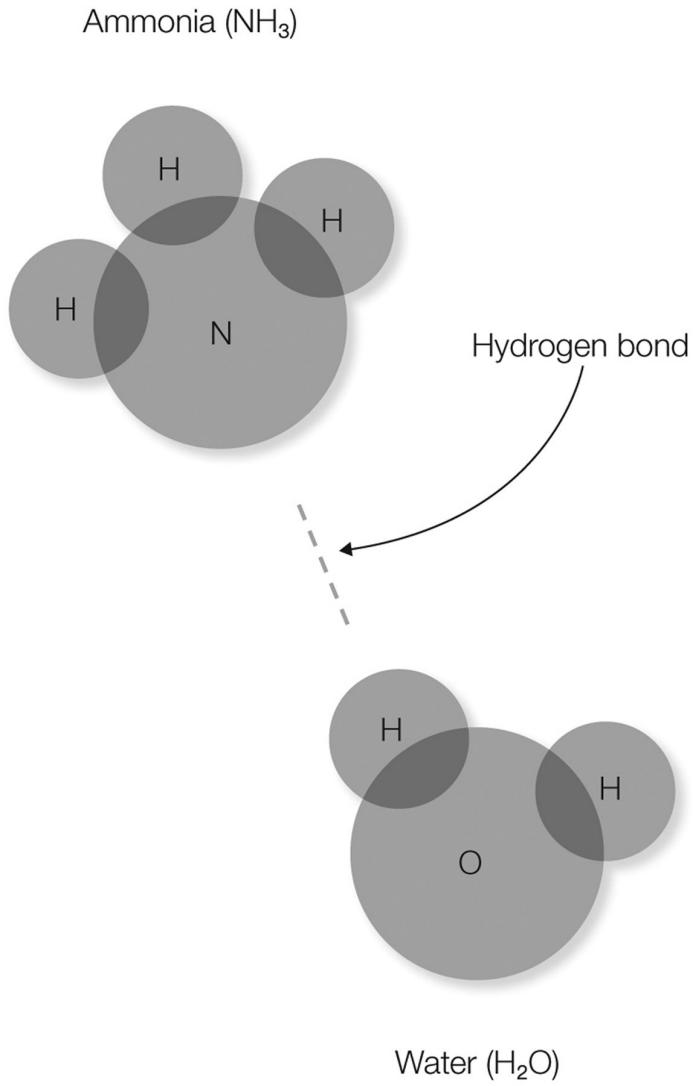
Answer: C

18) In a polar covalent bond,

- A) electrons are shared unequally between two atoms.
- B) electrons are transferred from one atom to another.
- C) an acid and a base neutralize each other to form a salt.
- D) electrons are shared unequally between more than two atoms.
- E) electrons are shared equally between two atoms.

Answer: A

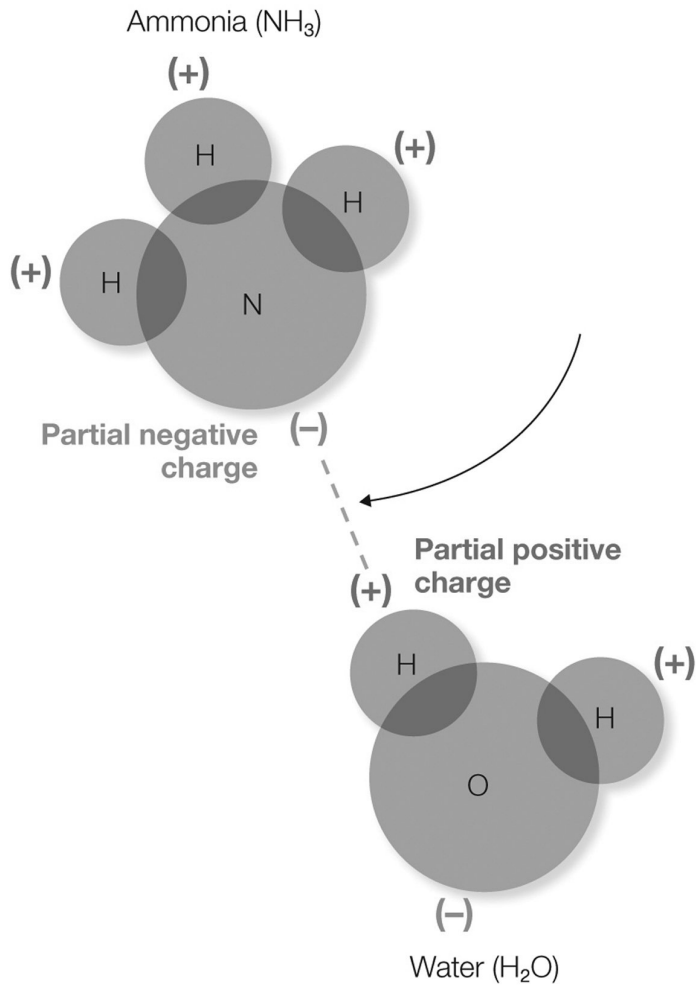
19) In the figure shown, which atom(s) will have a partial negative charge?



- A) nitrogen and oxygen
- B) hydrogen
- C) hydrogen and oxygen
- D) oxygen
- E) nitrogen

Answer: A

20) In the figure shown, what does the dotted line represent?



- A) transfer of the electron from the hydrogen atom to the nitrogen atom
- B) sharing of electrons between the ammonia and water molecules
- C) a Van der Waals interaction
- D) an electrostatic interaction between the partially-positive hydrogen and the partially-negative nitrogen
- E) an interaction between a hydrophilic and a hydrophobic molecule

Answer: D

21) Hydrogen bonds

- A) form whenever hydrogen is involved in any covalent or ionic bond.
- B) are involved in stabilizing the structure of proteins and nucleic acids and form whenever hydrogen is involved in any covalent or ionic bond.
- C) are responsible for the unique properties of water.
- D) are responsible for the unique properties of water and are involved in stabilizing the structure of proteins and nucleic acids.
- E) are involved in stabilizing the structure of proteins and nucleic acids.

Answer: D

22) Van der Waals interactions

- A) are responsible for the repulsion between hydrophilic and hydrophobic compounds.
- B) exhibit a force of repulsion that serves to destabilize molecules.
- C) are another name for hydrogen bonds.
- D) occur when temporary dipoles within molecules form that are not the result of hydrogen bond to O, N, or F atoms.
- E) are stronger than either hydrogen bonds or ionic bonds.

Answer: D

23) Which term is incorrectly matched to its description?

- A) Amphipathic: Has properties that are neither hydrophilic nor hydrophobic; hydrophilic: substances which readily dissolve in water; AND hydrophobic: substances which are not readily dissolved in water are all incorrectly matched
- B) Hydrophobic: Substances which are not readily dissolved in water
- C) Hydrophilic: Substances which readily dissolve in water
- D) Amphipathic: Has properties that are neither hydrophilic nor hydrophobic
- E) Hydrophilic: Substances which readily dissolve in water AND hydrophobic: substances which are not readily dissolved in water are both incorrectly matched.

Answer: D

24) A micelle is formed of

- A) both hydrophilic and hydrophobic molecules.
- B) hydrophilic molecules only.
- C) amphipathic molecules where the hydrophobic portion faces toward the center.
- D) amphipathic molecules where the hydrophilic portion faces toward the center.
- E) hydrophobic molecules only.

Answer: C

25) Plasma membranes, the key boundary layer of cells, are composed of amphipathic molecules called phospholipids. Why would neither purely hydrophilic nor purely hydrophobic molecules be a suitable molecule for plasma membranes?

- A) Hydrophilic molecules would dissolve in the aqueous environment in which cells live, disrupting the structural integrity of the cell.
- B) Hydrophobic molecules would dissolve in the aqueous environment in which cells live, disrupting the structural integrity of the cell, while hydrophilic molecules could not interact.
- C) Hydrophilic molecules would dissolve in the aqueous environment in which cells live, disrupting the structural integrity of the cell, and hydrophobic molecules would be unable to interact with the aqueous environment in which cells live.
- D) Hydrophobic molecules would be unable to interact with the aqueous environment in which cells live.
- E) Both hydrophilic and hydrophobic molecules would dissolve in the aqueous environment in which cells live, disrupting the structural integrity of the cell.

Answer: C

26) Consider the reaction  $AB \rightarrow A + B$ . What is the product of this reaction?

- A) A
- B) B
- C) AB
- D) A and B
- E) A, B, and AB

Answer: D



27) Which reaction has X and Y as reactants?

- A)  $XY + W \rightarrow WY + X$
- B)  $XY + AB \rightarrow XB + AY$
- C)  $XY \rightarrow X + Y$
- D)  $X + Y \rightarrow XY$
- E)  $X + YZ \rightarrow Y + XZ$

Answer: D

28) Which statement does not describe a catalyst?

- A) A catalyst is not used up in the reaction.
- B) A catalyst will increase the rate of a reaction.
- C) A catalyst may be an inorganic substance.
- D) A catalyst may be an organic substance.
- E) A catalyst will decrease the rate of a reaction.

Answer: E

29) Which reaction is incorrectly matched with its name?

- A) Double exchange:  $AB + CD \rightarrow AD + CB$
- B) Hydrolysis:  $A + B \rightarrow AB + H_2O$
- C) Synthesis:  $A + B \rightarrow AB$
- D) Single exchange:  $AB + C \rightarrow AC + B$
- E) Decomposition:  $AB \rightarrow A + B$

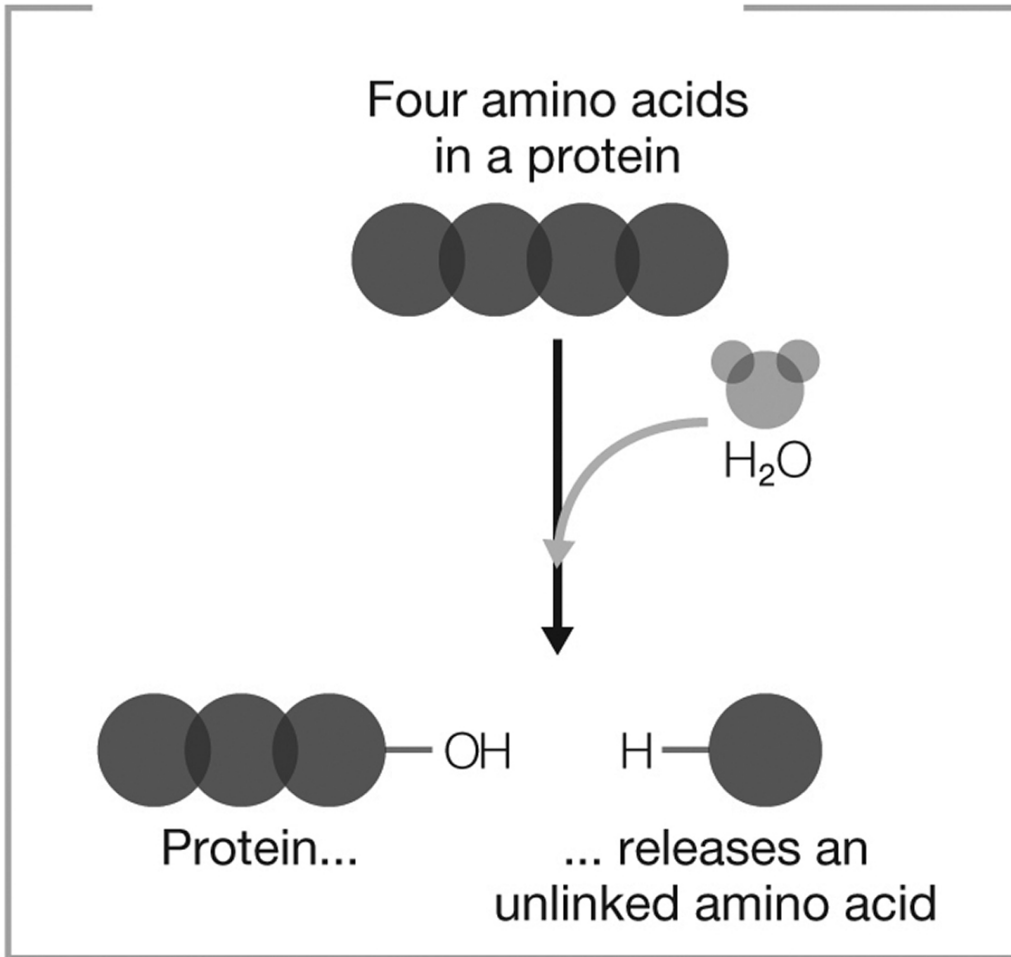
Answer: B

30) In a dehydration synthesis reaction, macromolecules are built when \_\_\_\_\_ is removed to form a covalent bond.

- A) an electron
- B) carbon dioxide
- C) water
- D) an amino acid
- E) oxygen

Answer: C

31) What type of reaction does the figure show?



- A) decomposition and hydrolysis
- B) dehydration synthesis
- C) dehydration synthesis and hydrolysis
- D) decomposition
- E) hydrolysis

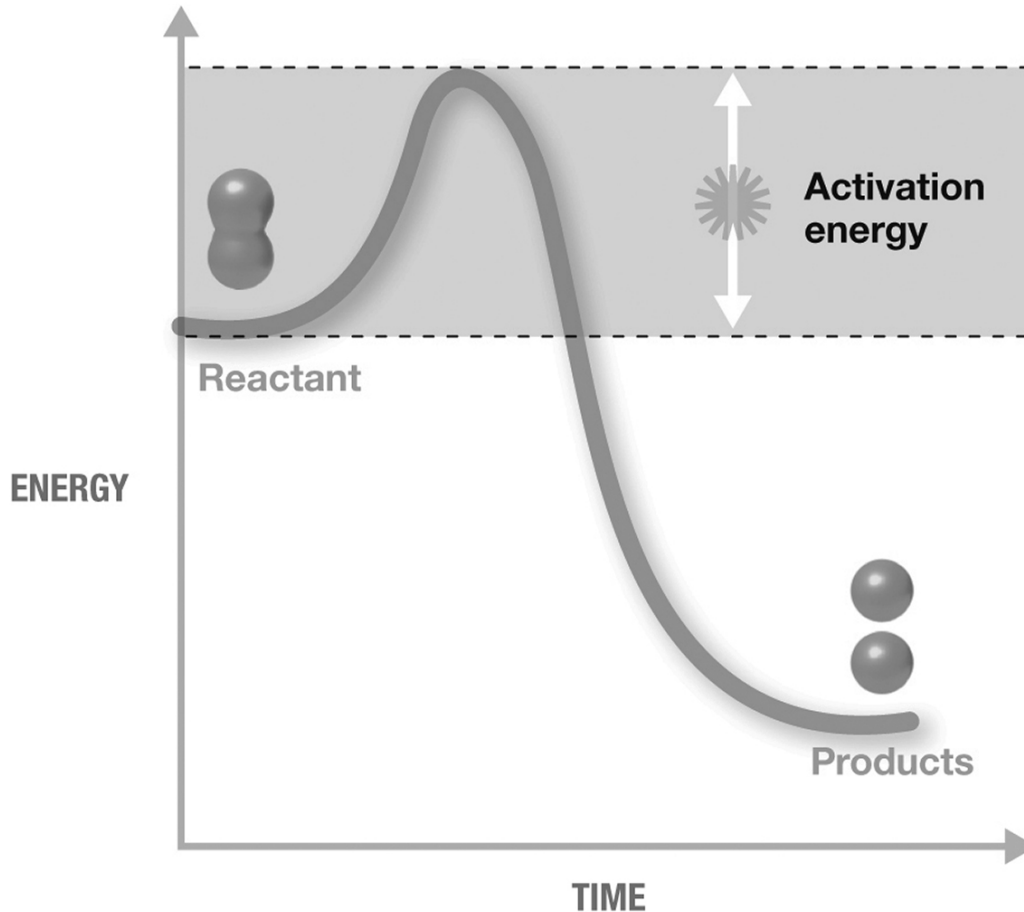
Answer: A

32) Activation energy

- A) is the minimum amount of energy needed to get a reaction started and is due to the necessity of collisions between reactants which have enough energy and with the reactants properly oriented and can be lowered by catalysts such as enzymes in biochemical reactions.
- B) can be lowered by catalysts such as enzymes in biochemical reactions.
- C) is due to the necessity of collisions between reactants which have enough energy and with the reactants properly oriented.
- D) is the minimum amount of energy needed to get a reaction started.
- E) is the minimum amount of energy needed to get a reaction started and is due to the necessity of collisions between reactants which have enough energy and with the reactants properly oriented.

Answer: A

33) The figure shown is an exergonic reaction because



- A) activation energy was required.
- B) it is a decomposition reaction and the products have a lower final energy than the reactants.
- C) it is a decomposition reaction.
- D) the products have a lower final energy than the reactants.
- E) activation energy was required and the products have a lower final energy than the reactants.

Answer: D

34) Which of the following does not describe equilibrium?

- A) A forward and reverse reaction occur at the same rate.
- B) when there is an equal amount of products and reactants and a reaction has stopped
- C) A reaction has stopped.
- D) The total amount of products and reactants is no longer changing.
- E) when there is an equal amount of products and reactants

Answer: B

35) Which of the following is not one of the four main groups of biomolecules?

- A) nucleic acids
- B) carbohydrates
- C) electrolytes
- D) proteins
- E) lipids

Answer: C

36) Which of the biomolecules is incorrectly matched with its building block?

- A) Protein: Amino acid
- B) Lipid: Fatty acid
- C) Lipid: Glycerol
- D) Nucleic acid: Nucleotide
- E) Carbohydrate: Polysaccharide

Answer: E

37) The type of bond which links the amino group of one amino acid to the carboxyl group of another amino acid is called a(n)

- A) glycosidic bond.
- B) amino bond.
- C) peptide bond.
- D) glycerol bond.
- E) phosphodiester bond.

Answer: C

38) Which statement is true about carbohydrates?

- A) They may be saturated or unsaturated.
- B) They are a component of the cell wall of different types of organisms.
- C) They have primary, secondary, tertiary, and quaternary structure.
- D) They are usually hydrophobic.
- E) They consist of simple sugars which contain carbon, hydrogen, and oxygen in a 2: 1: 2 ratio.

Answer: B

39) Which type of lipid is incorrectly matched to its description?

- A) Mono-, di-, or triglyceride: One, two, or three fatty acids linked to a glycerol molecule
- B) Steroid: Made of four fused hydrocarbon rings
- C) Phospholipid: An amphipathic lipid found in the plasma membrane of cells
- D) Wax: Refers to any lipid which is solid at room temperature
- E) Glycolipid: A lipid linked to a carbohydrate

Answer: D

40) Deoxyribonucleotides and ribonucleotides differ in all of the following except

- A) phosphodiester bonds can only form between deoxyribonucleotides, not ribonucleotides.
- B) deoxyribonucleotides are found in DNA while ribonucleotides are found in RNA.
- C) the sugar is different in the two types of nucleotides.
- D) ribonucleotides can serve as energy molecules while deoxyribonucleotides do not.
- E) the nitrogenous base thymine is only found in deoxyribonucleotides while the nitrogenous base uracil is only found in ribonucleotides.

Answer: A

- 41) Plasma membranes must be in a fluid (liquid) state in order to function properly. Fluidity is temperature-dependent. Bacteria can regulate the specific lipid composition of their plasma membranes. Which of the following statements is true?
- A) The proportion of saturated lipids in the plasma membrane will increase with both cooler and warmer growth temperatures.
  - B) The proportion of unsaturated lipids in the plasma membrane will increase with warmer growth temperatures.
  - C) The proportion of unsaturated lipids in the plasma membrane will increase with cooler growth temperatures.
  - D) The proportion of saturated lipids in the plasma membrane will increase with cooler growth temperatures while the proportion of unsaturated lipids will increase with warmer growth temperatures.
  - E) The proportion of saturated lipids in the plasma membrane will increase with cooler growth temperatures.

Answer: C

- 42) The primary structure of a protein
- A) is the linear sequence of amino acids which are held together by peptide bonds and is dictated by genetic sequence.
  - B) is the linear sequence of amino acids which are held together by peptide bonds and is dictated by genetic sequence and is unique to that protein and lays the foundation for all higher order structure of that protein.
  - C) is the linear sequence of amino acids which are held together by peptide bonds.
  - D) is unique to that protein and lays the foundation for all higher order structure of that protein.
  - E) is dictated by a genetic sequence.

Answer: B

- 43) Which level of protein structure can involve hydrogen bonds?
- A) primary
  - B) secondary
  - C) tertiary
  - D) primary and secondary
  - E) secondary and tertiary

Answer: E

- 44) In the human genetic disease sickle cell anemia, a single change in the genetic sequence of the hemoglobin-beta gene results in the amino acid valine being substituted for the amino acid glutamic acid in the beta chain of the hemoglobin protein. Which level(s) of the protein structure will be affected?
- A) primary structure
  - B) secondary structure
  - C) tertiary structure
  - D) quaternary structure
  - E) primary, secondary, tertiary, and quaternary structures

Answer: E

- 45) Chaperone proteins
- A) escort proteins to the location in a cell where they are needed.
  - B) ensure that a protein is folded correctly.
  - C) ensure that amino acids are placed in the correct order when forming a protein.
  - D) cleave a phosphate from ATP to release energy.
  - E) ensure that DNA molecules form double-stranded helices.

Answer: B

TRUE/FALSE. Write 'T' if the statement is true and 'F' if the statement is false.

46) A cation forms when an atom loses one or more negatively-charged electrons.

Answer:  True  False

47) Water (H<sub>2</sub>O) and carbon dioxide (CO<sub>2</sub>) are both molecules and compounds.

Answer:  True  False

48) A molecule of glucose contains six carbon atoms, twelve hydrogen atoms, and six oxygen atoms. The proper way to write the molecular formula for glucose is <sup>6</sup>C<sup>12</sup>H<sup>6</sup>O.

Answer:  True  False

49) Acids increase the H<sup>+</sup> concentration in a solution and so lower pH.

Answer:  True  False

50) Blood pH is stabilized by carbonic acid (H<sub>2</sub>CO<sub>3</sub>) which releases H<sup>+</sup> ions to lower pH and bicarbonate (HCO<sub>3</sub><sup>-</sup>) which absorbs H<sup>+</sup> ions to raise pH.

Answer:  True  False

51) During vigorous exercise, both carbon dioxide and lactic acid enter the blood in increased amounts. Both compounds have the effect of lowering the blood pH. In order to maintain blood pH within the normal range of 7.35-7.45, we would expect the carbonic acid (H<sub>2</sub>CO<sub>3</sub>) portion of the blood buffer system to pick up the extra H<sup>+</sup> ions.

Answer:  True  False

52) In a polar covalent bond involving hydrogen and oxygen, the hydrogen takes on a partial negative charge while the oxygen takes on a partial positive charge.

Answer:  True  False

53) Endergonic reactions make products with a lower final energy than the reactants and use more energy than is released.

Answer:  True  False

54) A reversible reaction is one in which the forward and reversible reactions are both possible such as: AB → A + B and A + B → AB.

Answer:  True  False

55) A phosphodiester bond links a fatty acid to a glycerol molecule to form a fat or an oil.

Answer:  True  False

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

- 56) Describe the relationship between acids, bases, salts, and water, and explain how the pH scale is used to measure acidity and basicity.

Answer: Acids are substances that increase the concentration of hydrogen ions ( $H^+$ ) when dissolved in water. Bases are substances that increase the concentration of hydroxide ions ( $OH^-$ ) when dissolved in water. When an acid and a base are mixed, the result is a salt and water. For example: hydrogen chloride + sodium hydroxide  $\rightarrow$  sodium chloride and water or  $HCl + NaOH \rightarrow NaCl + H_2O$ . The pH scale measures the amount of  $H^+$  ions in an aqueous solution. Neutral pH is defined as 7.0 where the amount of  $H^+$  ions and  $OH^-$  ions are equal; this is the pH of pure water. Acids lower pH values; values below 7 are considered acidic and lower numbers are more acidic than higher numbers. Bases raise pH value; values above 7 are considered basic and higher numbers are more basic than lower numbers. The pH scale is a logarithmic scale, so each whole number step pH represents a tenfold change in acidity or basicity.

- 57) Compare and contrast ionic bonds, covalent bonds, polar covalent bonds, and hydrogen bonds. Explain how valence electrons are involved in the formation of each.

Answer: Chemical bonds form between two atoms to form molecules. Chemical bonds form by the action of the valence electrons, those found in the outer shell of each atom. Atoms combine in a way to achieve full valence shell which is the most stable configuration for atoms.

Ionic bonds are electrostatic forces of attraction between a cation and an anion. These bonds form when or more valence electrons are transferred from one atom to another. The receiving atom becomes the negatively-charged anion while the donating atom becomes the positively-charged cation. Covalent bonds are electrostatic forces of attraction between atoms that share one or more pairs of valence electrons. The two atoms may share the paired electrons equally or symmetrically in which case the covalent bond is referred to as nonpolar. Conversely, the shared valence electron pair may spend more time orbiting one of the atoms in the pair than the other. This causes the first atom to acquire a partial negative charge while the other acquires a partial positive charge. In this case, the covalent bond is said to be polar. Hydrogen bonds are not really bonds but are noncovalent electrostatic interactions between atoms in two different molecules or within the same, large molecules. Hydrogen bonds form because of the partial negative or positive charges that occur on polar molecules. In particular, when hydrogen is bonded to either oxygen or nitrogen, the hydrogen becomes partially-positively charged, while the oxygen or nitrogen becomes partially-negatively charged. The attraction of the oppositely charged atoms forms the hydrogen bond.

- 58) Vitamin deficiencies (not getting enough of a certain vitamin) pose obvious health problems, but an excess of certain vitamins in the system can also be harmful. Explain why you would be far less likely to experience an excess of water-soluble vitamins compared to fat-soluble vitamins in the context of the characteristics of polar and nonpolar substances.

Answer: Water-soluble vitamins are polar molecules which dissolve in water (hydrophilic). They are easily excreted from the body in the urine, and therefore are unlikely to build up to toxic levels. Fat-soluble vitamins are non-polar. They do not dissolve in water (hydrophobic) and so are not easily excreted in urine. Instead they are stored in fat, where it is possible for them to build up to unsafe levels if an excess amount is ingested over a period of time.

- 59) List the four types of biomolecules. For each type, name the monomer building block, the type of chemical bond which joins the building block, and give two functions, naming a specific example where appropriate.

Answer: The four types of biomolecules are carbohydrates, lipids, nucleic acids, and proteins.

(1) Carbohydrates include monomer building blocks called monosaccharides, or simple sugars which usually have 3, 5, 6 or six carbons along with hydrogen and oxygen in a 1: 2: 1 ratio. A monosaccharide may join with another monosaccharide through a glycosidic bond to form a disaccharide; multiple monosaccharides chain together through glycosidic bonds are called polysaccharides. Carbohydrates are the chief energy sources in biological systems, serve as structural biomolecules, and mediate cellular adhesion, communication, and environmental sensing. Glucose is a favorite energy source for cells while cellulose, peptidoglycan, and chitin are all constituents of cell walls. (2) Lipids are a group of mostly hydrophobic molecules including fats, oils, waxes, and steroids. Lipids such as fats and oils are composed of fatty acid chains attached to a glycerol molecule through an ester bond. The fatty acids may be saturated (no double bonds, i.e. the maximum possible amount of hydrogen is bonded to each carbon atom) or unsaturated (one or more double bonds, i.e. less than the maximum number of hydrogen atoms bonded to each carbon atom). Fats and oils serve as energy sources for cells, as cell structure components, and mediate cell signaling. Waxes are fatty acids bonded to a long-chain alcohol; they serve a variety of protective functions. Steroids are composed of four fused hydrocarbon rings; they are involved in cell signaling pathways. (3) Nucleic acids come in two varieties: DNA and RNA. Both are composed of polymers of nucleotide monomers. Nucleotides are held together in chains through a phosphodiester bond. Each nucleotide is composed of a pentose sugar (deoxyribose or ribose), 1 -3 phosphate groups, and one of five nitrogenous bases. DNA serves as the genetic blueprint for all cells and some viruses; RNA can serve as the genetic blueprint for viruses and directs the production of proteins in all cells and viruses. (4) Proteins are polymers of amino acids joined in a chain by peptide bonds. The sequence of amino acids used in a given protein is unique to that protein and determines the structural and functional characteristics of that protein. Proteins typically fold into specific three-dimensional structures which are determined by the amino acids found in the protein. Proteins may serve as structural scaffolds in cells, as enzymes facilitating chemical reactions, cellular transporters, and are involved in cell recognition and communication.

- 60) List and describe the four levels of protein structure. Explain how the levels of structure are dependent on each other and describe what types of molecular interactions are involved.

Answer: The four levels of protein structure include primary, secondary, tertiary, and quaternary structure. (1) Primary structure is the linear sequence of amino acids in the protein, which are linked together by a type of covalent bond known as a peptide bond. A protein's primary structure is unique to that type of protein, and the overall structure and function of the protein results from the properties of each amino acid in the protein. All higher levels of protein structure are dependent on specific interactions between particular amino acids, so the primary structure of a protein determines its secondary, tertiary, and (if applicable) its quaternary structure. (2) Secondary structure consists of regular, consistent coils or folds in the protein chain which are held together by hydrogen bonds between amino acids. Types of secondary structure include alpha-helices and beta-pleated sheets. (3) Tertiary structure is the folding of the protein chain upon itself to form a characteristic three-dimensional structure. These structures are formed by both covalent and noncovalent interactions between specific amino acids. Not all proteins display quaternary structure. (4) Quaternary structure occurs when two or more separate polypeptide chains combine to form a functional protein. Both noncovalent and covalent interactions are involved in quaternary structure.